

TECHNICAL EDUCATION OF THE PEOPLE IN UNTECHNICAL LANGUAGE.

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by C. BAILLAIRGÉ.

While the Royal Society of Canada, like its prototype of England, cannot descend to the education of the masses of mankind; it behoves It, though, as occasion may offer, to be suggestive of any improved mode of doing so.

Persons not destined to become scientists, professors or even professional men or women, must nevertheless be educated to an intelligence of the phenomena of life; and it cannot be derogatory to the dignity of a society like this, to point out how it can be done without resorting to what is termed technology or technical tuition in the true sense of the word.

“ Tyndall, says Spencer, possessed this faculty in a high degree. This constructive imagination, says he—for we are not concerned with mere reminiscent imagination—here resulting in the creations of the poet and there in the discoveries of the man

of science, is the highest of human faculties. In common with successful investigators in general, he displayed it in forming the conception of physical processes previously misinterpreted or uninterpreted ; and again in conceiving modes by which the actual relations of the phenomena could be demonstrated ; and again in devising fit appliances to this end. But to a much greater extent than usual, he displayed constructive imagination in other fields. He was an excellent expositor, and good exposition implies much constructive imagination. A prerequisite is the forming of true ideas of the mental states of those who are to be taught ; and a further prerequisite is the imagining of methods, by which, beginning with conceptions they possess, there may be built up in their minds the conceptions they do not possess. Of constructive imagination as displayed in this sphere, men at large appear to be almost devoid ; as witness the absurd systems of teaching which in past times, and in large measure at present, have stupefied and still stupefy children, by presenting abstract ideas before they have any concrete ideas from which they can be drawn. Whether as lecturer or writer professor Tyndall carefully avoided this vicious practice.

Mankind at large has a desire to understand the every-day rising of the sun and going down of the same, the phases of the moon, the wherefore of the tides, the origin of rivers and their ceaseless flow ; the shape, size, formation of the earth and how its component rocks, its coal, its minerals have come to be.

It is not necessary he should be told how our

system is supposed to have been brought about by an aggregation of cosmic matter, or that Earth and Sun and planets are travelling together toward the constellation Hercules; but it is pertinent for him to know something about his own make-up or constitution : his osseous, muscular, nervous, digestive, vascular, venous and arterial systems ; that he may understand his ailings and minister to his requirements.

He must be made acquainted with the composition and whereabouts of the component materials of his calling as of those of others. A knowledge of stone and wood comes to him of itself, he being in contact with them from earliest childhood ; but not so of glass, brick, delf, lime, paper, leather, cotton silk, etc. ; while wool may be surmised from being seen hanging to the very sheep it comes from, as feathers from birds, furs from our domestic animals ; and even woven fabrics may be guessed at, as to how and of what made up ; by noticing the component separate threads, interlacing with each other like the wicker work of a basket.

The object lessons of the Kindergarten are necessary at all ages : blocks to build up varied forms, balls and marbles to teach action and reaction, the angle of reflection equal to that of incidence, the parallelogram of forces. Refraction can be taught in a tea-cup ; or when at play, illustrated by a stick thrust into a well or pond or river. There need be no technical terms made use of to illustrate the centre of gravity or how it is found.

It is for the man of science to point out, suggest to the ordinary teacher how object lessons are to be imparted for the tuition of the million. Two men bearing on their shoulders, a log or other object larger at one end than the other, may think and sometimes do, that each bears half the weight ; but let them lay it down and lift one end of it and then the other, as of a tapering spar, when they will be quick to see the difference and then take turns at shoulder-
ing opposite extremities.

Let any man be asked to cut into parts of equal cubical contents, a crooked or tapering stick of timber, as a sawlog, or find the centre of gravity or balancing point of a gun ; he may not readily think of or hit upon the plan of balancing it on a pivot, as you would a spoon or fork on the edge of a knife if required to divide it into parts of equal weight.

It is for the man of science, the technologist to reduce these things to writing, that the teacher in the kindergarten, the giver of the object lesson may know what to do and how to impart the knowledge.

In very many things, technical tuition by the man of science is not required. The teacher can himself read up and see and tell how brick and delf and pottery and glass are made, and impart the knowledge direct to the pupil ; and better still, he should see it done and take the student where he may see it also. He can explain how cotton grows and where and how made into thread and web, or warp and woof and tissue. He can tell how silk is spun and

what the silk worm feeds on ; how leather is of tanned hides and how made into boots and shoes ; how logs are cut into boards and made up into huts and houses and into furniture ; how glass is blown into bottle form or cylinder, the ends cut off, the cylinder split open, flattened out into sheets ; how plate glass is cast and rolled and polished ; how the metals, like glass can be fused, run into molds ; how paper is made up of rags and how rolled into sheets and again how type is put together into words and lines and pages and printed on the paper and made into books.

He can tell his pupils where coal comes from and that it is not a manufactured article, or not made up by man, but formed in Earth's laboratories by natural elaboration and the lapse of ages ; how lime is made of stone by baking it and thus driving off its carbonic acid gas component.

He can tell, explain a thousand things, ten thousand without the aid of the technologist ; but can he tell how the coal came there, of what it is composed ? No ! he must here take his clue from the geologist who will tell him of the woods and forests or plant life of the earth, of its waters, of how the waters are evaporated into clouds and wafted by the winds to colder mountain heights, where the vapor is condensed again and falls as rain, runs off into rills and rivulets and rivers, carrying with it earth and sands disintegrated from the parent rock by wind and wet and frost and other agencies ; how these have formed deposits which ages and pressure and chemical action have hardened into stone.

Let the geologist write up in ordinary phraseology the history of the world : that is, a mere synopsis of it, or as much of it only as is required to be known or can be taken in, retained by men who have had no classical education, cannot afford it or have no time for it even if they could ; so much as a man, a farmer or mechanic or intelligent laborer should know or is desirous of knowing, that he may not be or appear to others absolutely ignorant of the surrounding world.

We need not go back to the very chaos of Genesis ; but start with the supposition that Earth was made a molten globe with vapor all around it, condensing into water as the crust cooled down into what we now call granite. Our every-day fellow man can understand this and how the inner workings of the material in fusion, have done on a grander scale what volcanoes and earthquakes are still doing in a diminished way ; to wit : have thrown the crust or rind of the earth into humps and ridges ; precisely as the crust upon a pie is upheaved into hummocks, fumeroles by the action of the imprisoned steam beneath.

The waters of the earth will now have settled into the hollows, forming seas and lakes and oceans, and have left dry the protruding continents and islands.

The unequal surface velocity of rotation at and near the equator and in higher latitudes, and the action of the sun, will have caused winds, the winds waves, the waves disintegration of the coasts; and

that, with the detritus brought down by rivers from the heights to which the wind driven evaporation from the waters has ascended, the superstrata or layers above the granite.

Forests now appear and let it be by the fiat of the Creator. They grow for ages, luxuriant in heat and carbonic acid gas until some cataclysm, some mighty cyclone, may-be, fells them to the earth, and there they lie and rot and are elaborated into peat and lignite and finally into coal, or may-be the process of transformation is not as yet complete when by surface subsidence the strata go beneath the waters; and are in time covered by other sedimentary deposits, in their turn to become, as before, hardened into stone.

The surface is upheaved again and other forests formed which again in turn are elaborated into coal and so on through countless ages, forming alternate layers of coal and stone for man's future requirements.

And when the waters have sufficiently cooled down, they are peopled with mollusca; later on with fish, the mammoth whale and some other mammalia; the air with winged life, the land with quadrupeds, etc, until finally man appears upon the earth and finds every thing provided for his existence: his nourishment in its surface soil, its fish and fowl and other animal food; wood for constructive purposes, and stone; coal for fuel in its bowels; and in its veins and fissures gold and silver, copper, ores of iron and other metals and some of them found native; the

skins and furs of animals to cloth his nakedness, and preserve his bodily heat, and a benign creator to care for all his needs.

Nor will our pupil be slow at understanding how, if we can not tell the absolute length of life of mountain chains, there relative ages may be proclaimed by a study of the nature and number of the non conformant strata lying at their bases; while the relation of these strata to each other in regard to priority of formation is evidenced by the progressive or gradual transition from the first, the lowest forms of life, to the higher and more perfect forms found imbedded in the strata; and an examination of existing glaciers and of their moraines will leave no doubt in the man's mind as to how the great erratics, the monstrous bowlders to be met with in our latitudes, have been torn from the mountain summits to the North of us, and moved southward by the rivers of plastic slowly flowing ice of the so called glacial epoch, as evidenced by their abraded surfaces and rounded angles, the striæ along their route; and as the author is witness to every year, by bowlders from Carouge and higher up the St. Lawrence which become frozen in the under surface of the batture or shore ice and several of which have been thus transported and dropped on the very beach opposite his country residence, som 20 miles below, and some of these again taken up and moved still further by a similar or analogue process.

The astronomer now steps in and in a concise and plainly written form, instructs the teacher how

to explain the motion of the earth upon its axis and around the sun, making use of some such simile as that of a bycicle coursing around a circular path with something in the centre illustrative of the sun—a gas or an electric light for instance, making the simile more natural—where the progressive motion of the cycle is illustrative of that of the planet around its primary, its motion in a twelve months ; the revolution of the larger wheel, the earths' rotation on its axis, its daily motion ; while the small or steering wheel may represent the satellite or moon accompanying the earth, revolving also as it goes ; and on account of the differing velocities of the two wheels around their respective axes, the larger thus successively presenting every portion of its periphery to the smaller, producing the effect of the moon's rotation about the earth.

But this revolution of the earth about its axis may be ocularly demonstrated in an hour or less by a rehearsal on a smaller scale of Foucault's experiment of the pendulum in the Pantheon, and which the writer often had occasion to repeat when giving lessons to his pupils in engineering and surveying, to wit : by suspending an iron or a billard ball or any other, by a string to a nail or hook in the ceiling of his studio, starting it to oscillate, say in a direction parallel to one side of the room or apartment, or to one of the component flooring boards or ceiling battens, or to a line or straight edge on a table beneath the ball ; when it will be noticed that in less than one hour, in fact, in the fraction of an hour a consider-

able variation in the direction of the swinging plane has taken place ; and, that the rotation or twisting of the suspending string does not affect the direction of the plane of oscillation may be seen in a few seconds by any one holding up his watch by the end of the chain, causing the watch to oscillate as the pendulum of a clock, while at the same time twisting the chain around between his fingers.

Or, and as he has also often done himself in lecturing on astronomy to his students : let there be upon a stand in the centre of a room a candle, lamp or other source of light and let this be the sun ; then through the shorter diameter of an apple or an orange or through and through the stem or axis thrust a knitting needle, or the handle of a pen, incline it as required to the angle of elevation of the pole and holding it constantly parallel to that direction, or pointing to the pole of the heavens or supposed to be, walk around the luminary with this simile of the earth, rotating it the while in your fingers, around its axis, and you illustrate in this way day and night at any one point : their equality at the equinoxes, their disparity at the solstices and show how one pole is lighted at one season of the year and the other when you are half way around the sun ; a clove, a tack or the end of a match stuck into the apple in your own latitude representing the position of the observer.

And in the same or a similar manner can the phases of the moon be made plain and how eclipses of the sun and moon occur, total, partial, annular, and how the discovery of the velocity of light was

brought about by Roemer, while comparing the actual and calculated or tabulated times of occultation of the satellites of Jupiter or of their eclipses, and reappearances, and what that velocity is and how arrived at.

No endeavour need be made to cram your man with such abstruse subjects as aberration and nutation; nor is it necessary that the average pupil be told what means the term “precession of the equinoxes and of its period of 25,000 years or so”; but tell him of our planetary system, its component members, their approximate relative sizes and distances.

A word about Venus may not be out of place and of how, being an inferior planet or between us and the sun, it can never vary its apparent distance from the latter by more than a given angular amount or distance, being thus some times in the twilight an evening, then a morning star; while the superior planets, like Jupiter may be seen at all angles from the sun or even in almost direct opposition to it. All this can be shown on a table or the floor with the help of a few balls or marbles or an orange for the sun; and even without such adjuncts, by a mere pencil sketch on paper; though better, quicker and easier of apprehension by the concrete method of the objects in relief.

Now in geometry, the pupil can easily be made to see how the three angles of a plane triangle make up two right angles, by cutting off and putting together the component angulars of any triangle drawn on paper, or on cardboard or on the easily to

be divided lid or botton of an ampty cigar box or sheet of tin or the like ; and how, by assuming the diameter of the earth's orbit about the sun, as a base line, taking one angle now and the other six months hence, the third or angle at the apex is obtained, and how the distance of the sun thereby compares with the length of base assumed and how it thus becomes known. The practical man will not yearn for any thing more than this, he will not care to be told how this distance may also be obtained by a transit of Venus or of Mercury accross the sun's disk. He is now ready to admit that one can reach he stars and measure them and their distances from us and from each other and understand what mean such distances when expressed in terms of the velocity of light.

Latitude can easily be made plain to our man as being equal to the angle of elevation of the pole or of Polaris when on a horizontal line with the former or when in elongation, or as he would be told, discarding technical phraseology : when on a line parallel with the horizon or perpendicular or at right angles to a plumb-line ; by showing him that from pole to equator being 90° or a right angle, and from zenith to horizon also a right angle ; therefore taking equals from equals, the remainders must be equal.

Our pupil young or old can soon be made to see and in fact is likely to see for himself that the earth revolves, and from West to East in 24 hours of his clock time ; and kuowing that a circle is divided into

360 degrees, is not slow at discovering that every hour corresponds to 15° , every minute of time to 15 minutes of space or longitude or to the quarter of one degree, and he can then understand how the captain by his chronometer can tell his longitude at sea ; he now appreciates the necessity for the utmost precision in such time keepers, their setting and rating, and he sees how longitudes of places can be compared under the times simultaneously telegraphed by the instantaneous flash of electricity.

But there are matters for the million where the data to be used cannot be obtained nor taught by elementary modes and where calculus of the highest order must be resorted to, as in the preparation of the nautical almanac or ephemerides, for the guidance of the mariner at sea and the determination of the exact figure of the earth, and relative positions of points upon its surface. The untutored may smile incredulously at such an apparently useless array of figures involved in the obtaining of the time or exact longitude, and at that, of only one single spot on the earth's surface ; but when he reflects, that the earth being only about 25,000 miles in circumference, a minute of the compass is but the 21,600th part of the circle and can be but slightly greater than an ordinary mile — 6076 ft. instead of 5280 — or what is called a knot, a marine, nautical or geographical mile ; a second of space or the 60th part of a minute, only 100 ft. ; and when he recollects that an ocean greyhound now leaps over or covers this distance of 100 feet in 2 seconds of time ; he sees, he

fully takes in and appreciates that fraction of a minute which may lie between his vessel and a breaker, between a live craft and a wreck, in one word, between life and death ; and it is thus the vulgar become wedded to the necessity for accuracy so unerring.

Again our man or pupil, and without more technology than the mere mention of the thing, may be made to see at a glance how spherical areas are arrived at ; for, first, to see that the area of a plane triangle is just half that of its corresponding parallelogram requires no geometrical endeavour. Now, do not tell him that the area of a circle is equal to the square of the diameter into decimal .7854 or about $78\frac{1}{2}$ per cent of its enclosing square. He will not understand that as it is not brought home to him by his own process of reasoning ; but what he can see, the argument reaching the mind through the eye, is that the area of the circle is equal to its circumference into half the radius ; for he will mentally or with pencil parcel it out into triangles by drawing lines from the centre to the circumference, and of each of the components the area is that of the base into half the height or radius—and thus he also sees that the area of the semi-circle and of the sector is to be arrived at by a like process of the length of arc into half the radius. The segmental area strikes him at once as the difference between that of the sector and that of the triangle ; and the area of a lune is, in an analogous manner, made just as plain to his untutored perception, as the difference between a semi-circle and a segment on the same base, by a mere repetition of the process for the segment.

Here then arrive we at the component triangular spaces into which the surface of a ball, or sphere, the earth may be divided or of which a spherical or spheroidal area as that of a melon, an orange may be conceived to be made up; for this very structure exists in nature in the component ungulae or wedged like shapes or solids of which the ribbed melon is composed; and the orange after the removal of the outer skin or rind, reveals the same wedge-like structure, the base or surface of each elemental ungula, supposing it developed, being like unto a double segment or two segments base to base, or the middle section of a prolate spindle by a plane through its longer axis, affording thus an idea of how to get its area.

But to do the thing correctly, and so, more easy: let this surface of the ungula be cut in two at the equator or half way between its poles or apices, and we have two spherical triangles, where the pupil on being told of it, will see that the angle at the apex is the so called spherical excess, or the excess over two right angles or 180° ; for, as is evident the angles at the base of every such component triangle of the hemisphere are both right angles as of all meridians where cut by the equator; and as their respective areas vary as the angles at the apices or summits, therefore becomes it evident even to the non technologist that the areas of spherical triangles are proportional to their respective spherical excesses and that this is also true of spherical polygons; and now, beginning with the area of the tri-rectangular triangle or one eighth of the whole sphere; dividing it by 90, we get the area of a bi-rectangular of which

the spherical excess is one degree, the 60th part of this being for one minute, the 60th of this last for one second and, shifting the point: the 10th, the 100th, the 1000th of this for the corresponding decimals. These figures of course are for the sphere of which the diam. is 1 or unity, so that squaring the diameter whatever it may be and multiplying, our practical mechanic can arrive by a mere addition of the tabulated areas, or rather by first multiplying the respective figures for one degree, one minute, one second and its unit decimals by the number thereof in the given spherical excess, at the area of any component section of the earth, a dome or other figure of the kind however large or small.

And in another direction, the practical mechanic with a little elementary geometry, may be led to work out a variety of problems. For instance, it so happens that the square of the hypotenuse or largest side of any right angled triangle is equal to the sum of the squares upon the other sides, and therefore can a right angle be laid out by the aid of any three numbers as 3 and 4 and 5 or of any multiples thereof, enabling our man to calculate the length of ladder needed to reach a certain height, or length of stay or strut or brace or inclined member or diagonal; and the perpendicular in a semi-circle to any point in the diameter is a mean proportional between the parts of said diameter. Applying this, the radius of a railway curve can be found by measuring the length of cord or straight line joining any two points in the curve, and the versed sine or distance at the centre

of the cord between it and the curve ; when, squaring the half cord and dividing by the versed sine, and extracting the square root or looking for it in existing tables for the purpose. there comes the balance of the diameter which adding to the versed sine and halving the result, gives the radius required ; and in a similar manner could the size of a tree be arrived at of which there remained but a portion of the stump.

Now going into physics, to vary the tuition, and not tire out the individual by dwelling too much at length on one and the same theme : the pressure of the atmosphere can be illustrated by rolling a sheet of paper into a cylindrical or tube-like form, applying it air tight to the palm of the hand at one end, applying the mouth to it and sucking out the air at the other, when it will immediately collapse or the opposite sides of it come together at the centre.

Suction and the common pump may be illustrated by a straw, or better by a glass tube with coloured liquid — the weight of the air and amount of pressure at the level of the earth, by a comparison with that of a column of water sustained in a vacuum, and proved again by the relative weights of water and of mercury and the corresponding heights of these substances in their respective tubes. Thus also will be understood how a siphon or curved pipe or conduit with its bend or apex upwards, and on condition that its vertical height do not extend beyond that to which, under the pressure of the atmosphere, water will ascend in a tube devoid of air, may be made to

empty out a lake or reservoir, or pour one sea into another ; provided the air be pumped from it, and the height of the intervening ridge or ground not more than 30 feet above the level of the water drawn from, unless dug into or tunneled for the purpose, the delivery leg of the siphon longer than the other and the surface of the water in the river or lake pumped to, at all times below that of the lake or pond or sea pumped from, with both ends of the siphon, of course, always under water.

And he can see for himself if incredulous of telling, that this pressure of the atmosphere, as shown by a barometer decreases as he ascends to mountain heights or balloon altitudes; and will then be ready to give credence to the assertion of the man of science, that though at 5 miles high one half the weight of air is left below one, the upper portion from its less density may and probably does extend to some 50 miles above the surface ; while his conception of the phenomenon may be enhanced by the simile of a depth or height of 50 ft. of feathers, or even of a room full, which however light or almost without weight at top, a person lying under would certainly feel the weight of.

Our pupil will now see how the barometer can be applied to the measurement of altitudes and atmospheric pressures ; he will notice how when rising, the surface of the mercury in the tube is convex and the contrary or concave when falling, and will thus know if the mercury be rising to fair or falling to foul weather ; and he will gain credence, confidence

in the foretelling of the weather by the bureau of meteorology or so called Govt. Observatory, founded on observations of the behaviour of the mercurial column under vicissitudes of rain and shine and wind and calm.

He will now be ready to admit that water must boil or bubble under a less pressure of the air at an elevation above the earth's surface, and that it therefore can not be made hot enough to scald, unless under an air tight cover heavy enough to stand the uplifting force of steam at 212° or that of water boiling at the earth's surface; or if not heavy enough, to be tied or weighted down till the water is hot, and that this again must afford, which it does, an approximate mode of estimating altitudes; and thus all the phenomena of heated and lighter air and water will be made easy to him, and why smoke ascends and balloons follow suit; and will understand the spontaneous rising of hot water to distribute heat through our dwellings; and ventilation, and how air may be compressed and used for motor power, and even liquified by cold and pressure, and water frozen and water vaporized or made steam of and its force increased indefinitely by boiling under pressure; a foot of snow being considered equivalent to an inch of water, a cubic inch of water to a cubic foot of steam, a foot of air an ounce or so, specific gravities and the like.

And how much more of a popular nature may be imparted without the aid of science proper, and in fact almost every thing an intelligent man or woman, laborer or mechanic may care to know about; for

instance : put one pin in a table through a sheet of paper and with a string and pencil show how a circle of any radius may be laid out on the ground. Now put in two pins at a distance between them and let the string or rope be of the full length of the transverse or longer diameter of the proposed ellipsis, and join the ends or tie them to the pins and with the string held taut and the pencil or graver carried around, you will have laid out the curve, such a one as you obtain on obliquely cutting through a cone, or through a well made beet root, carrot, parsnip, or even the handle of a broom or the like.

Our pupil will now see that each of the radii vectores—call them plain radii or rays or lines drawn from the centres or the foci — makes an equal angle with the circumference or curve, or more correctly with the tangent drawn through the point of contact ; and if he has forgotten the lesson : than the angle of incidence is equal to the angle of reflection ; illustrate it to him again with a ball and straight edge, or to make the simile more perfect, curve the ruler or a mere plasterer's lath, maintaining it in position by three or more nails ; when our man will see that as to all appearances the lines from the foci do meet the outer edge of the figure under equal angles, therefore that a ball, if projected from one focus towards the periphery, will rebound and reach or pass through the other focus, and he will understand how as well as balls, rays of light and heat and sound from one focus must be repercussed towards the other, rendering plain to him the coveted secret of the

whispering gallery in St. Paul's Cathedral, London ; as well how under circumstances analogous, a person may be heard better at a greater distance than if nearer by.

Again, this double centred curve is that in which our Earth and all the planets travel round the sun, our moon around its mother Earth, and all the satellites as of Jupiter and other planets, about their primaries ; and from a few points in this magic curve, its whole periphery can be traced out ; yes : in the same way as the engineer, given three points in his curve, can run it out for miles if necessary, amidst the waters and the forests of the Earth ; so can the astronomer trace out among the starry forests of the heavens, the path of each member of the solar system ; and when a comet heaves in sight, tell its velocity, to within what distance it will approach the sun situated in one of its foci, its excentricity or distance of the focus from the centre of the curve, and finally both of its diameters and the total circuit or periphery of its orbit around the sun ; and predict with almost unerring accuracy when it will heave in sight again, on its return trip to our sun, and even though it should be absent for a hundred years or more.

Now for the parabola, the section of a cone by a plane parallel to its slant side — cut one from a well conditioned elongated turnip or a beet-root after parting or paring off the head — the pupil has no use for knowing what an ordinate or an abscissa is, or that the square of the former is in constant ratio with the

latter. From the nature of the section he will see that it is and must be an open curve of which the legs can never come together but must go on, if prolonged, widening their distance to infinity, and he will then see how, if a comet travel in an ellipsis around the sun, it must again heave in sight some day ; while one coming towards us along one leg of a parabola, and after circuiting around the sun, its focus or its centre, must leave us to return no more ; unless as in political astronomy it be swerved from its course by side issues on its way.

Again, trace out the parabola on paper or a board, not by the scientific modes of doing so, and may-be too abstruse to understand or teach ; but by applying the solid section or portion cut from the cone with its face towards the paper, and run your pencil round its margin. Now assume the focus ; but that your man may not be led to think that it can or should be found by fudging, point out to him, whether he is likely to remember it or not, how this centre can be got by simple geometrical construction : halving an ordinate, drawing from the half point a line to the summit or apex of the curve, and from the same half point, a perpendicular to this to meet the axis or median line, at a point the distance of which from the assumed ordinate equals and gives the distance of the centre from the apex. From the focus draw a line to any point in the curve, and from that point a parallel to the axis, and tell him again that each of these lines makes equal angles with the curve, and that the angle of the incident ray being therefore equal to that of the reflected, a ball or ray of

light or sound projected or sent forth from the focus to the side, will rebound or go off in a direction parallel to the central or the median line of the parabola.

And if this parabolic paper section be cut out and made to stand on end, or even half of it, and it be turned or swept around, we shall be in presence of the so called paraboloid, illustrative of which a tumbler, tea cup, or a ladle may do duty ; and as all sections of it through the vertical or axis must be and are alike, our pupil will now see how, if the summit or the apex of an elongated figure of the kind be cut away and the mouth applied just at the focus, we have the speaking trumpet in which, instead of the sound spreading on all sides, as where uttered in the open, its vibrations are concentrated by the tube and the whole force of the voice thus turned in any required direction and therefore heard at a much greater distance.

And he will see and understand how, as in a light house, the rays from the focus of the fire, instead of spreading as do those of the sun and moon and stars, or of a lamp or candle towards all points of the horizon and up and down and every where ; will on the contrary, after striking the curved surface of the purposely made paraboloidal reflector, be concentrated into a bundle, so to say, and thus go forth on their errand of humanity.

He will be ready now to grasp the idea of how a stone projected obliquely upward into space, and which, if there were no retardatory causes, would hurry on in the same straight line in the direction

pointed to, does, under the influence of gravity or of its own weight, curve more and more as it ascends, towards its mother planet, until it reaches to the summit of its throw, and then it falls again, describing as it descends, the self same curve, but facing or turned the other way, each half the counterpart of its fellow, each half the half of a parabola, and of the same parabola ; or, falling beyond the vertical through the apex of the curve, to the self same distance it was projected from ; and thus will he understand how the artillerist can, with a ball or shot of given weight, and given force of powder impact and at a given or calculated angle or inclination upward from the horizon, be made to fall just where required into the stronghold of the enemy on land or into a ship at sea, of either of which there are many quick and simple modes of ascertaining the distance off.

Our every-day man can be taught by simple means how to tell his distance from a far off object of which he knows the size or height. The difficulty often times is not in doing but in conceiving how and what to do. If he is told that sound travels, say in round numbers 1000 ft. per second, and is taught by observing the pendulum of a seconds clock, to beat seconds in his mind, and audibly to his own hearing by saying 0, 1, 2, 3, 4, 5 &c., or told to make a pendulum for himself with a plumb bob, or stone and line of given length (39.1383" or $39\frac{1}{4}$ "), he can then calculate how far off is the thunder bolt by the lapse of time between the instantaneous light of flash and sound thereof ; and if miles away when he can hear the midday gun, his miles into seconds will tell him

just how much past noon it really is or should be by his watch when the sound reaches him.

And when I say that to count seconds, one must begin with nought or zero, it is that to appreciate the first interval, there must be a starting point, and whether audibly or mentally, it must be said or thought, or the first second cannot even be approximately guessed at.

Our hankerer after knowledge had thought before this lesson on the velocity of sound, that the discharges of a line of musketry were successive as the sounds thereof, and could not make out how it should be possible for each succeeding shot to be fired in so small a fraction of a second after the one immediately preceding it, and be succeeded at equal intervals by the next and next and next; but now he understands that the firing is really simultaneous along the line, and that it is because, of his position at one end of the line or further off, that the sounds reach his hear successively, due to the increased distance each has to travel. And if he be posted near the centre of the column; then will he hear a double series of separate reports reaching him simultaneously in pairs proceeding from the centre or point opposite to him and successively towards each extremity of the line of fire.

Echo may also be here explained as existing when a sound reaching and being reflected back from a non absorbent rock or wall, &c., is heard a second time; provided the point from which the sound goes forth is at a distance of at least 90 ft. from the repeating

or percussive surface; as, if not, the echo and the sound would be heard together and confounded with each other, and this echo may be several times re-echoed as the celebrated Woodstock echo repeating 20 times, while that at Simonetta castle near Milan reechoes 40 times.

An inkling can also be imparted of how the vibrations of chords of stringed instruments as violins, guitars, harps, pianos, &c. produce sounds, the lowest noise audible as a continued sound by a string stout or long, or just taut enough to vibrate 16 times in one second of time, the octave by doubling the number of vibrations, and the successive octaves by doubling and doubling again, and by making the strings successively thinner, shorter, tauter; and how the intermediary notes of the octave are due to numbers of vibrations of intermediate frequency but proportionally so between those of each successive octave, and how when a string tuned to a certain pitch, becomes elongated more or less under continuous fingering or striking by a piano hammer, the note becomes false, flat if too loose, sharp if too taut and has to be rectified by tightening or loosening the screw or key, an operation called tuning; and while on the subject of vibrations, our friend may be made to understand that in an analogous manner the component colours of white or sun light, travelling as it does at 180,000 miles in one second of time, in undulations of say one 40,000th inch ampl. more or less, strike the retina with the tremendous and to us incomprehensible velocity of 500 millions of millions of vibrations in a second; the greater or less frequency of vibration in

that unit of time, producing in us the impression of the component colours of the rainbow or those into which white light is decomposed by a prism of glass, and how.

What has already been said of bundling together rays of light to do duty in a light house, is sufficient for the pupil to conceive and admit how by the use of lenses of certain forms and at certain distances apart, telescopes are constructed to aid the eye in reaching, seeing to greater distances, microscopes to magnify.

The eye retains the impression of an object seen or looked at, during one eighth of a second of time. This tells how many optical illusions are to be explained ; as of a continuous line or circle or other figure produced by the quick brandishing of an incandescent coal, or of a stick one end of which has been thrust into the fire, and while still aglow, moved through the periphery of the figure described in the eighth part of a second, or made continuous by moving the luminous point eight times per second. This retention of the impression by the retina, produces the effect, when passing rapidly in a railway train through an iron lattice or trussed bridge, that all the diagonal members or struts and ties are being thrown into a violent state of oscillation or wave or whip-like motion.

Another effect the writer has noticed is that in passing rapidly before a pile of pipes with their ends or apertures turned towards you, the circular openings appear oval or elongated in the direction of your motion.

The magic wheel or cylinder where objects and animals may be seen in motion, though at a stand still in the picture, is explainable in the same manner.

In dealing now a day with such quick travelling matters as light and electricity 180,000 miles in one second of time, and of the millions of vibrations per second of the retina caused by the entrance into the eye in that time of as many undulations or waves—one may make some approach to a conception of such a subdivision of the second of time by considering that one can easily during two beats of the seconds pendulum, count to ten and even to twenty, but as two tens, to avoid the delay of the two syllable numbers from 12 to 20. Now take a book containing say 1000 folios of thin paper in an inch; and holding it, so the thumb will touch the corners while they are made to pass under it, will be a division, a sensible and visible division of the second into a thousand parts, if it took a second to do so; but this can be done in the 10th part of a second or 10 times in one second and thus we arrive at the division of the second into 10,000.

Again let a wheel be supposed of which the periphery or circumference is 1000 inches, and each inch milled into 1000 parts, this fraction of an inch being conceivable by the above mode of 1000 folios of thin paper to an inch. The whole periphery is therefore divided into 1000×1000 or 1,000,000 parts. This circumference of 1000 inches gives a diameter of only $26\frac{1}{2}$ ft. or so, and as such a wheel might be made to revolve once per second; we thus arrive at a, so to say, ocular proof or conception of the division

of a second of time into a million parts. Again, as gold leaf is supposed to be only the 100 thousandth part of an inch in thickness, there would be 100 of them to each folio or leaf of our supposed division of the periphery into 1000 parts per inch and thus the mind is capable of conceiving such minutia as the 100 millionth of a second, and the 100 thousandth of an inch in space.

Well, our object-lesson pupil has now been taught many things ; but to make his teachings general, let us hint at how, as well as lines and areas both plain and curved, he may also cover solids; and to this effect give him but one rule for all, as he was taught one rule for all areas, by computing and putting together the component triangles of which every area can be conceived to be made up. The prismoidal formula is what is required, where only plane areas are to be made up; or when circular, segmental, elliptical or the like, found ready made in books, the areas added, their sum multiplied and the product divided, all by simple arithmetic ; and when dealing with complex forms, how to be sub-divided and the contents added or their differences taken.

And as said before, the duty of the technologist or scientific man is to suggest simple modes of doing things which the kindergarten teacher may not dream of ; such as cubing a piece of statuary, a chair, a plant-like form, a man or living animal, by putting it or him into a tub, or box filled with water or with sand and note the difference of level when taken out.

Teach the mechanic, the founder how to compute

in advance the weight of an intricate casting of ornamental schroll work from that of the model, by their respective specific gravities or weights and a simple rule of three. How a rough stone picked from a quarry on the roadside may be cubed if necessary by an arithmetical comparison of its weight with that of a cubic ft. or inch of the same material under the heading of specific gravities; and how, conversely, without any means at hand of getting at the weight of a tub of butter or other article capable of being cubed, the weight itself would follow by mere comparison with that of a foot or inch of like material.

The delivery of a stream or river, by its area of cross section into its average velocity in ft. or yards per second or per minute, and the whole into horse power by the height in lbs. into the head or height of fall and a division of the foot-pounds by the ordinary assumption of 33 or in round numbers say 30,000 lbs. raised one foot high in one minute of time.

The draught of a pontoon or vessel by a computation of its weight and a comparison thereof with that of water.

A mental process for instance of arriving at the weight of a foot in length or area of iron or other scantling, by simply bearing in mind the weight of a cubic ft. thereof, say 480 lbs., being 40 lbs. for an inch-foot area, 5 lbs. for a foot square and $\frac{1}{8}$ thick; whence for instance a bar $3 \times \frac{3}{4}$ will give for one ft. of it the quarter of 15 lbs. and the same size scantling if of wood at 48 lbs. per cubic foot, one tenth of such result.

Fraunhoffer's lines would be greek to our individual ; but he must be told what they mean and how by the help of them we know the component materials of other worlds.

And now let him know something of his own make up : of how he breathes and what ; how the atmosphere is a mixture of oxygen and nitrogen or azote, say one to four with some carbonic acid gas ; how the latter is destructive of animal life and to be detected in a well and accidents avoided by trying with a candle or a lamp let down into it, it being heavier than air and settling to the bottom, or how in a cellar a dog may breathe and die of it or be affected more or less, or himself if lying down, while if standing he may breathe above it and not succumb — how the oxygen of the air he inhales or takes into his lungs acts on the blood it comes in contact with and brightens it and vivifies and robs it of its carbon ; the mixture forming carbonic acid gas which he expels in expiration, and how, illustrative of the saying that “ one man's meat is another man's poison ” this gas deleterious to man, is life to vegetable nature which also breathes' as we do, but taking in the acid and expelling oxygen.

How the heart is made up of compartments : a double pair of force pumps, receiving the new blood fresh from the lungs on one side, pumping it from the other into the arteries which reach to every portion of the body ; whence it returns to the heart, taking up on its way all impurities, passes to the other side and then is forced towards the lungs where its dross passes

out in exchange as already said for the brightening and vivifying oxygen of the inspired air.

And by looking throught your eyelids at the sun, you can see the blood, its red and minute corpuscles, 600 to the lineal inch ; or each of the tiny rings or discs the one six hundreth of one inch in breath ; and how they float and are in ceasless motion in the containing whitish serum of the life sustaining fluid which reaches, permeates every, the minutest portion of the tissues ; as evidenced by the fact that you can not at any point prick the skin with the finest or the tiniest of needles, without the blood issuing or oozing from the aperture ; and withal, another proof of how the eye can take cognizance of such a minute portion of an inch, and of diameter only equal to the tickness of the thinnest paper.

How his aliments pass after mastication and salivation from the mouth into the stomach where they are acted on by the gastric juices ; thence through the pylorus into the duodenum or larger part of the digestive tube, and into and by peristaltic action, through the 30 ft. or more of the small intestine or ileum so called, the capillary lymphatics and the lacteals, on the way, taking up the alimentary matter which they pour into the venous blood on its way back to the lungs where it is to be elaborated into the arterial fluid, while the unnutritive elements pass along to be expelled, as ashes are from the furnace when the gases of the coal or wood or oil have been abstracted from them in the process of combustion : a similar to that at the lungs where the oxygen of the

air burns out the blood impurities; and while creating the necessary heat for the sustenance of the animal temperature, expels the carbonic acid gas, the product of such combustion.

As to magnetism, no more need be imparted than that it is an attraction exercised by certain substances on certain others, as illustrated by a load-stone or by a straight or horse-shoe magnet; that there exists terrestrial magnetism which causes the so called magnetic needle or compass to point in a particular direction or more or less towards the north point of the horizon; and that this fact is taken advantage of by mariners at sea, surveyors and engineers on land, to direct their course through the oceans and forests of the earth when other means are not at hand for doing so.

Electricity must be alluded to: even the otherwise uneducated man is not satisfied if he have not at least an idea of what it is and how it acts. Its existence can be illustrated by a little friction of certain substances the one against the other. The friction of the penknife against the sharpening pencil electrifies it and causes the chippings to adhere. The rubbing of paper by caoutchouck to efface a pencil line, electrifies it and causes it to adhere forcibly to the table. The moment our pupil sees what it is on a small or feeble scale and how it acts by attraction and repulsion, he is ready to believe that it may exist in nature on a much grander scale, and that instruments can be made to create it in large quantities. The spark elicited from stroking the feline species, almost

invisible and feeble though it be, is sufficient for him to believe in the possibility of electric lighting; and that from the clouds only adds to his conviction. Let it but be shown that electricity can flow and has a tendency to do so, through metallic wires or conductors, and that the electric current turns soft iron into magnets which can and do attract a lever at either end; he is ready to admit that it may flow a thousand miles or ten and repeat beyond the ocean what it does at the other end of a room or table; and he sees how with a point at the end of the lever, and as you dwell upon it for a less or greater time, this point on a roll of paper moved by clock work, must produce dots and dashes easily translatable into ordinary language.

And now man's nervous system may be dwelt a while upon, and how the bones are hollow and let pass the marrow made up of bundles of nerves of sensation and of motion, all arising in the brain: the seat of mind or head quarters of the individual; how this, as with the veins and arteries, is like unto a tree, its ramifications reaching every, the minutest portion of the body and the most remote; every nerve corresponding to some particular portion of the brain whence the will can telegraph to all portions of the structure, setting them in motion, and the sensations of every kind be conveyed back to the seat of all intelligence.

There are various other subjects to be explained but we have not time for all; and in writing out a treatise for the purpose the technologist will hit

upon modes and similes by which the intelligence of the subject matter of tuition may be imparted in a, so to say, popular way or *à la Franklin*, *à la Tyndall*, *à la Faraday* ; remembering in his teachings, as suggesting to the would be teacher of the masses, with, may-be, nothing at hand to do so with, no instruments, no models, no apparatus ; how the first object at hand or in sight may be made to do duty as said before : as a broom handle for a cylinder, a beat-root, parsnip, carrot for a cone ; an orange for a sphere and its component ungulæ, a pencil in a cup of water for refraction, a bit of mirror for reflection, a lath and marble for action and reaction, a taut string between the fingers for a straight line, a folded sheet of paper for a ruler or straight edge, while a double fold brings forth a right angle or a pair or 4 of them when developed, another fold an angle of 45° , and so on ; a lamp or other source of light, the sun ; a cup for a paraboloid, a string, a pulley and some weights, a hammer, nails, etc ; a book illustrative of how small thicknesses or amplitudes may be conceived or measured by piling them together and counting the number of them in an inch or in a given portion of an inch and other self suggestive modes to the technologist by which he may make his meaning full and facile of understanding.

And further to help our man in the conception of infinitesimals, direct his mind to the fact that in the seed must be the elements of every portion of the plant or tree : its trunk and branches, twigs and leaves and blossoms. Look at the insect you can

hardly see with the naked eye : it also has its organisms of vitality—heart and lungs and circulation of the blood, its digestive apparatus and its nervous system ; and if its whole body be but the 100th of an inch or the 6000th part of the lineal dimensions of a man or of any animal of like dimension, and the blood corpuscles in proportion to its size of veins and arteries which in us and them are the 600th of an inch, then must our man admit that these same corpuscles in the insect can be but the 3,600,000 of an inch. And in a manner, may-be, more sensible by being visible to the eye and which can be felt and handled ; take the result at which the gold beater, the maker of gold leaf or gilding gold, arrives, when he has spread out his $\frac{5}{8}$ " cube of solid gold into a sheet 20 ft. square and therefore 400 ft. in area, in which the $\frac{5}{8}$ " area is contained 147,000 times and—you cannot deny your senses—the tickness of the leaf can not exceed the 236,000th part of an inch. Apply the same process to a drop of soap suds : this you can blow into a bubble of such diam., that the thickness of the film will hardly exceed the millionth of an inch and there you see it and can touch it and have proof positive of the truth of the assertion.

What precedes is all in the way of “ object lessons ” (*leçons de choses*) but there are other lessons quite as important to be taught, and which do not seem ever to have been dreamed of as yet by any one, or to form part of any system : I allude to “ word lessons ” (*leçons de mots*) or what should or might be called such. Children of many years of age : 10, 15 and

even 20 and many of maturer age ignore the meaning of hundreds of words with which they should be made familiar and without a knowledge of which they never can be considered as having a practical education, fitting them for the duties and conceptions of every-day life. They do not understand what they read; they cannot join in conversation nor appreciate, for they know not the meaning of many of the words made use in their surroundings. The writer has been witness to and noticed this for 40 years past in his own family and the families of others. Children at school and college and in convents know their catechism and their history and grammar and they can read correctly and fluently of a story, tale or novel where the words alluded to do not occur and if they do or did their meaning is not, would not be understood, because forsooth the teacher knowing them, or may-be not, he or she, imagines that the pupil knows them also, and that it never enters his or her mind to tell the pupil what they mean. There are children by the thousand and up to all ages who can not read the time of day by clock or watch, unable to recite in succession the months of the year or even the days of the week. In fact they do not know what constitutes such subdivision of the year, or even what a year is, the equinoxes and the solstices, what the meaning is of such words and when the thing expressed occurs; what a bissextile year and why, or how made up. What are taxes; water, poor and school rates; and the answer to this leads to the explanation of: what a municipality, a city, town, a village and a ward, — a councillor, an alderman, a

mayor; a proprietor, an occupant, a tenant; what tithes are, excise, custom duties, protection as against free trade, an examining warehouse, goods in bond. Geographies now a day tell us that a territory ruled by a king, is called a kingdom; by an emperor an empire; but in other respects the difference between the former and between them and a president of a republic and their respective functions are not explained and never taught at school. What means a Legislature, a Government, the House of Commons, the House of Lords, Congress, a Senate, Privy Council, municipal or city council, a committee, a commission and the duties of the functionaries of all such; a diocese, a parish, township, a city or peoples' representative, a deputy, a legislative councillor, a senator, minister, a parliament, a session or a sitting; the Governor and his attributes; a minister of crown lands, public works, canals & railways, of the interior, of marine and fisheries, of mil & def; a secretary of state, an attorney or solicitor general; a whipper in, a sergeant-at-arms, usher of the black rod; the duties of a "speaker," a prime minister; a czar, mikado, sultan, bey, shah, dey; a mother country and a colony; the functions of a magistrate, a judge, a sheriff and the difference between a police court, the superior court and courts of revision, appeals, an exchequer court, the supreme court, a circuit court, the Crown and what not; and a thousand other things words, expressions never taught in schools and yet which should be: how wine and beer and cheese and butter, bread are made — whence come salt, coal oil, truffles, asphalt, cloutchouck; what is a manufac-

tory, a foundry, a smithy, puddling and rolling mills, etc.

Steerage, saloon, intermediate passengers ; shares, debentures at, above and below par ; discount, premium, at a ; dividend, stocks, bulls and bears ; flour, pork, etc., firm, easy, dull ; agent, edition of a book, newspaper, etc., editor, bail, security, cash, instalment — passenger, freight, mixed train — staff, med., Gov. Genls' — quarantine — wholesale — retail — bankruptcy — assignee — liquidation — liquidator ; to pay so much in the dollar, creditor, debtor, broker, stock broker ; — via, by the way of, by such and such a route — Gen. Frt. & Pas. Agt — to wire — to cable — going N., S., E., W. ; explain in what direction from place of publication — right, left bank of river — local mail, stopping at all places where there is a P. O. — docked : put into a dock — payable “ at sight ” — explain stock quotations (below, above par) — market quotations, market *weak*, barley *quiet*, corn *dull*, lard *firmer*, cotton *steady* ; — baled hay — hamper — crate (of delf, cabbage, etc.) ; an alias, an alibi, extradition — estate (so and so) insolvents — inventory — water tight (vessel) compartments, saloons *amidships* (less motion in pitching)

Now a very good way of teaching a host of such words is to give the pupil every day a lesson at reading portion of a common or ordinary news-paper : the advertisements more especially of every description where some one or other or several of these words occur. The moment a word heaves in sight of which you have reason to believe the reading pupil

probably does not know the meaning or acceptation or how it is to be interpreted under the circumstances; let the reader stop until the word has been explained and then proceed until another necessitates his ministry.

And look at the many abbreviations never found in reading history, stories and the like.— How can the child know unless told, that ss. is to be read steamship, Nfld., Newfoundland, Col. and Cal., Colorado, California, Ont. Ontario, B. C. British Columbia, N. S. Nova Scotia, Me. Maine, Vt. Vermont, Ar. Arizona, Ark. Arkansas, Wy. Wyoming, Md. Maryland, P. O. Post Office, P. Q. Province of Quebec, P. E. I. Prince Edward Island, Co. company, Bros, brothers, lb. pound, cwt. a hundred weight, a stone 14 lbs., a quintal 112 lbs. manfg. Co. manufacturing Co., C. P. R., I. C. R., Q. C., Quebec Central, G. T. R., U. P. R., P. S. post script, ad-addendum or addenda, H. M. S., His or Her majesty's ship Canada, Sappho, etc. — 7.55 P. M. — 3.02 A. M., M. D.— B. N. A. British North America — Phone 94, Telephone No. R. M. S. Royal Mail Steamer — brig. brigantine, etc.

In the foregoing, the author assumes that men, otherwise uneducated; and, possibly, not even knowing how to read or write; either for want of means, or time or taste or aptitude for such tuition; are nevertheless curious or desirous of understanding the salient traits of the phenomena of life.

He thinks they would be better for a certain amount of geometrical, physical, astronomical, geolo-

gical, biological and other knowledge; more satisfied with themselves, less jealous of their educated fellows; less liable, when left to their own communings, to brooding in ill humor over their evils real or imaginary, of nourishing ideas of communism, anarchy and mischief; their minds being then stored with materials for reflection on the greatness and goodness of the Deity.

The education of the masses should not go too far beyond mere reading, writing and arithmetic and the object-lessons here proposed. The injunction: "educate the people" must not be misinterpreted, as it certainly is in far too many cases. Education must be special to the calling of the individual, a truth which Lady Aberbeen is now trying hard to inculcate: servants, nurses, cooks must learn how to minister unto the wants of others. Too much grammar, literature, music, embroidery, conchology and the like, unfits the farmer's daughter for the duties of her husband's sphere in life. Collegial, University tuition are ill adapted to the farmers' son, if he is to follow in the footsteps of his sire; though enough of chemistry to be imparted in a few object lessons and enough of botany are essential to his success in agri., horti., sylvi. and arboriculture.

Let us beware of "too much education" there is a danger of overdoing the thing and thus causing or inciting our should be agriculturists to be dissatisfied with their parents' mode of livelihood, flocking towards cities and towns or populated centres; there to become second and third class professionals of

every hue, with little or nothing to do; with mischief and discontent and anarchical tendencies following in the wake. There must not be too much sacred history, too much catechism; sunday is the day for that: it is so by divine injunction; let week days be devoted to object lessons in sewing, gardening, cooking, and in the teachings of husbandry: as how to dig, and ditch, and drain and plough and fence in, and cultivate, and erect buildings for the farm, the whole in miniature while at school, and in reality thereafter, for let it not be forgotten that God has said "six days shalt thou labor" and good, hard, honest work is the prayer the most congenial to the Deity.

